FLOOD PLAIN MANAGEMENT SERVICES PROGRAM

FLOODING ANALYSIS OF THE GRAND LAKES AND MATAGAMON DAM EAST BRANCH PENOBSCOT RIVER, MAINE

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The U.S. Army Corps of Engineers conducted this study at the request of the Penobscot Indian Nation, under authority of the Flood Plain Management Services Program. The intent of this study was to evaluate the potential flooding impact in the East Branch Penobscot River for various drawdown scenarios at the source impoundments (Chamberlain Lake, Telos Lake and Grand Lake Matagamon). The analysis was conducted using available data from documented spring and fall storm events as well as a projected 100-year storm event. The drawdown analysis determined that filling the lake between 1 April and 1 May as opposed to 15 April to 1 June does increase the peak flood flows along the East Branch Penobscot River and at Grindstone, during an extreme storm event with snowmelt, by as much as 3 feet above typical spring flooding. The drawdown analysis determined that extending the maximum storage period of the lakes from 15 July to Labor Day minimally increases the peak flood flows resulting from fall runoff events along the East Branch Penobscot River and at Grindstone.

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FLOODING ANALYSIS OF THE GRAND LAKES AND MATAGAMON DAM EAST BRANCH PENOBSCOT RIVER, MAINE

BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS 01742-2751

APRIL 2003

FLOODING ANALYSIS OF THE
GRAND LAKES AND MATAGAMON DAM
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FLOODING ANALYSIS OF THE GRAND LAKE MATAGAMON DAM AND EAST BRANCH PENOBSCOT RIVER, MAINE

I. EXECUTIVE SUMMARY

This study evaluated the downstream flood impacts for various drawdown scenarios of the Chamberlain Lake, Telos Lake, and Grand Lakes and outflow from the Telos Dam and the Matagamon Dam located in Penobscot County, Maine (see Plate 1). The Matagamon Lake Association (MLA), current owner of the dam, has recently adopted a new water management plan for Grand Lake Matagamon and its outlet (East Branch Penobscot River). Compared to historical operations, the new plan includes changes in the timing and magnitude (lesser) of annual drawdowns of Grand Lake, and revised seasonal outflows. Since this region of Maine is susceptible to flooding from spring rain storms in combination with melting snowpack, and in the fall, from coastal storms that can have tropical characteristics and intense rainfall, concern has been raised by the Penobscot Indian Nation (PIN) (a member of the MLA), on behalf of MLA, as to the potential increase in flooding impacts resulting from long-term implementation of the new water management plan. The intent of this study was to evaluate the potential flooding impact in the East Branch Penobscot River for various drawdown scenarios at the source impoundments, using available data from documented spring and fall storm events, as well as a projected 100-year storm event.

The hydrologic model, HEC-HMS, was used to conduct the hydrologic flood analysis. Hydrographs generated in this analysis determined that sub-basins located downstream of the Matagamon Dam generate high peak flows that are synchronized with the recorded peak flows at Grindstone, while the Matagamon Dam peak outflow is not synchronized with the recorded peak flows at Grindstone. Therefore, flow released from the dam was determined not to be the primary contribution to recorded peak flood flows at Grindstone. The primary contribution to recorded peak flood flows at Grindstone is stormwater runoff generated in the downstream sub-basins.

Although flow released from the Matagamon Dam was determined not to be the primary contributor to recorded peak flows at Grindstone; flow released from the dam during a 100-yr storm event or a spring event with snowmelt is considerable.

The drawdown analysis determined that filling the lake between 1 April and 1 May as opposed to 15 April to 1 June does increase the peak flood flows along the East Branch Penobscot River and at Grindstone, during an extreme storm event with snowmelt, by as much as 3 feet above typical spring flooding. In order for peak flood levels to remain below Fortier's camp (one of four inhabited areas identified as vulnerable to serious flooding) first floor elevation, the East Branch Penobscot River flows released from the Matagamon Dam need to remain below 12,000 cfs (Table 17), which correlates to a drawdown scenario of the Matagamon Dam at elevation 652.0 feet

NGVD and the Telos Dam at elevation 943.0 feet NGVD (Table 16), see Section VIII.G for a detailed discussion.

The drawdown analysis determined that extending the maximum storage period of the lakes from 15 July to Labor Day minimally increases the peak flood flows resulting from fall runoff events along the East Branch Penobscot River and at Grindstone.

II. INTRODUCTION

This hydrologic and hydraulic analysis evaluated the downstream flood impacts of various drawdown scenarios for Chamberlain Lake, Telos Lake and Grand Lake Matagamon, located in Penobscot County, Maine. The New England District, Corps of Engineers (COE) conducted this study at the request of the Penobscot Indian Nation (PIN), under authority of the Flood Plain Management Services (FPMS) Program.

Three dams regulate outflows from these headwater storage lakes to Webster Stream and the East Branch Penobscot River. Two of these dams, Lock and Telos, are located on Chamberlain Lake, while the third, Matagamon Dam, is located downstream on Grand Lake Matagamon. A map of the Penobscot River basin is shown on Plate 1 and the East Branch Penobscot with tributary watersheds delineated is shown on Plate 2.

At the time that the Penobscot Indian Nation (PIN) requested this study, these dams were owned by the East Branch Improvement Company (EBIC), comprised of two entities, Bangor Hydroelectric Company and Great Lake Northern Paper Inc. In 1995, EBIC began searching for a new owner of the Matagamon Dam and the two upstream dams. In October of 2000, the Matagamon Lake Association (MLA) was formed, comprised of camp owner, tribal, and resource agency representatives, and subsequently acquired ownership (January 2001) of the Matagamon Dam from EBIC. In addition, ownership of the two upriver dams (Lock and Telos), has been transferred to the State Department of Conservation. The MLA has since adopted a new water management regime for the Grand Lake/Matagamon Dam segment of the system, which prioritizes fish and wildlife enhancement and essential flood control measures over the historical operational priority of providing storage for downstream hydropower generation.

The MLA has expressed concerns regarding changes in the timing and degree of annual drawdowns at Grand Lake and the potential for increased flooding impacts to properties along the East Branch Penobscot River downstream of the dam. This study evaluated the downstream flood impacts of various drawdown scenarios of the Telos Dam and Matagamon Dam, for both spring and late summer/fall season rainfall/runoff events. The specific tasks included in this study are as follows:

1. Determine subwatershed areas and hydrologic characteristics such that flow at the potential damage areas can be developed.

2. Develop hydrographs for a 100-yr flood, and a historic flood as data allows.

3. Develop a hydrologic model of the East Branch Penobscot River watershed including Chamberlain/Telos Lakes and the Grand Lakes. The model will allow for computing lake inflows and outflows as well as uncontrolled subwatersheds contributing flow to damage areas. The model will be calibrated to the extent that existing data allows.

4. Run the hydrologic model with a 2-foot drawdown, 4-foot drawdown, 6-foot drawdown, and an 8-foot drawdown at the Grand Lakes to evaluate the range of flooding severity and to determine the effect of different initial lake levels on downstream flooding.

III. DESCRIPTION OF STUDY AREA

A. General. The East Branch Penobscot River originates in the northern and northwestern part of the Penobscot River Basin. Upstream of Second Lake Matagamon (the upper leg of Grand Lake Matagamon), the East Branch Penobscot watershed consists of two distinct sub-basins. The more northerly sub-basin is unregulated, originates at East Branch Pond, and flows through Third Lake Matagamon to its confluence with Webster Brook (see below) at Second Lake Matagamon. The more northwesterly sub-basin begins at Allagash Pond and flows easterly through Allagash Lake and into Chamberlain and Telos lakes. In reality this inflow represents a diversion of water from approximately 240 square miles of the Allagash/St John River watershed into the Penobscot River watershed, via the "Telos Canal", which begins at Telos Dam. At this point, a portion of inflow/storage available at Telos/Chamberlain lakes is discharged from Telos Dam via the canal and into Webster Brook, with the remaining outflow passing via Lock Dam into the Allagash Wilderness Waterway and the St John River watershed. From Telos Dam, Webster Brook flows approximately 21 miles, through Webster Lake, to its confluence with the East Branch Penobscot (i.e. northerly) sub-basin at Second Lake Matagamon. Both sub-basins are sparsely developed, and though they contain some mountainous terrain, there is considerable natural storage.

From the outlet of First Lake Matagamon, the East Branch flows in a general southerly direction for 47 miles to its junction with the West Branch at Medway, and has a drainage area of 1,120 square miles. The East Branch proper, below Grand Lake, falls at an average slope of 8.8 feet per mile. The greatest fall in this reach occurs seven miles below the outlet of Grand Lake where there is a drop of 130 feet in 2.5 miles, or more than 50 feet per mile. The drainage area downstream of Grand Lake includes approximately 417 square miles of relatively steep mountainous terrain, therefore, contributing a significant volume and peak runoff rates to the East Branch at Grindstone.

B. Lock Dam, Telos Dam and Matagamon Dam Descriptions. The Lock Dam is located on the northeast shore of the Chamberlain Lake and was constructed in the 1840's to redirect water from the Allagash watershed to the Penobscot River. Lock Dam consists of an approximately 400-foot long earthen embankment with a maximum height of 14-feet. The section of the embankment is approximately 200-feet long and includes a 3-to-3.5-foot high irregular, vegetated, rip rap and soil parapat, which is approximately 5-feet

wide. The crest elevation is irregular but is estimated to be 946.5-feet NGVD on average. Discharge to the Allagash River is regulated with a 3-foot diameter, gated culvert spillway and allows a constant flow of 25 cfs to continue to the Allagash waterway for recreational purposes, the remaining flow is diverted to the East Branch Penobscot River watershed through Telos Dam.

The Telos Dam is located on the eastern shore of Telos Lake on Webster Brook The Telos Dam watershed has a drainage area of 240 square miles (Allagash sub-basin), as shown on Plate 2. The original dam was constructed in 1845 at the head of the canal linking Telos and Webster Lakes. The existing dam was constructed in the late 1970's or early 1980's and replaced the previous dam. Telos Dam is a rock-filled timber crib structure, 154 feet in length and 16 feet high. The dam contains a spillway (length unknown) and a top of crib elevation of 947.8-feet NGVD, providing 4.1-feet of freeboard during normal full reservoir levels, although the normal spring lake elevation is currently maintained no higher than 943.8 feet NGVD. The dam spillway sections are equipped with two 12-foot wide radial gates, three 6-foot wide slide gates, one 8-foot wide slide gate and a 40-foot long flashboard section with 1.5-foot high flashboards.

The Matagamon Dam is located on the East Branch of the Penobscot River in T6R8 WELS, Penobscot County, and impounds Grand Lake Matagamon, which includes First and Second Lakes Matagamon. The dam has a total drainage area of 496 square miles. The primary tributary to the Grand Lakes is Webster Brook, a connector between Telos Dam and Grand Lake. Other tributaries include the natural headwater reach of the East Branch Penobscot River, Hay Brook, Hinckley Brook, Boody Brook and Trout Brook. For hydrologic analysis purposes, the Matagamon Dam watershed was divided into two sub-basins: the Allagash sub-basin (240 square miles) and the Grand Lakes sub-basin (256 square miles) (see Plate 2).

The Matagamon Dam, constructed in 1941 is a concrete gravity structure, 218.5-feet long and 30-feet high and was built to replace the timber crib structure constructed in the 1880's. The spillway is 78-feet long, has a crest elevation of 655.0-feet NGVD and contains nine vertical lift gates 5-feet high x 7-feet wide. In addition, the dam has four 10-foot x 10-foot sluice gates plus a 10-foot wide x 7-foot high log sluice gate. The top of dam elevation is 665-feet NGVD with a maximum height of 25-feet. Pertinent data on the dam are presented in Table 1. A detailed layout of both the Telos and Matagamon Dams is presented in Appendix B.

C. Flood Damage Areas. Damage areas downstream of the Matagamon Dam are not definitively identified. It is believed that approximately 50 homes, seasonal camps, and businesses exist along the East Branch Penobscot River between Matagamon Dam and the town of Medway, Maine. According to the dam operator, the damage areas are most likely concentrated between the Matagamon Dam and 10 miles downstream, and a 15-mile stretch of the East Branch Penobscot River between Grindstone and Medway. Four specific areas that may be susceptible to flooding include the Matagamon Wilderness Campground and Store located immediately downstream of the dam, Muriel Fortier's Campground located approximately two miles downstream of the dam,

Bowlin's Sporting Camps, located approximately 10 miles downstream of the dam, and the Pine Grove Campground and Cottages, located along Route 11 approximately 5 miles upstream of the confluence of the East and West Branch Penobscot at Medway.

IV. CLIMATOLOGY

The Penobscot River Basin has a cool, semi-humid, continental climate that can be quite variable within the basin due to variations in elevation. The summers are generally cool and the winters severe, especially at inland points. The basin lies in the path of the "prevailing westerlies" and the cyclonic disturbances that cross the country from the west or southwest towards the east or northeast. The area is also exposed to occasional coastal storms, some of tropical origin that travel up the Atlantic seaboard.

The basin's average annual temperature is 42 degrees Fahrenheit (F). The range of mean monthly temperatures is wide, from 63 to 68 degrees F in July and August to 12 to 20 degrees F in January and February. Temperature extremes range from occasional highs over 95 degrees F to lows below –10 degrees F. Average annual precipitation is 41 inches distributed uniformly throughout the year. Most of the winter precipitation is in the form of snow. Annual snowfall varies from about 70 inches to 120 inches. Water content of the snow cover in early spring is about six to eight inches.

Table 1
Matagamon Dam Pertinent Data
Penobscot County, Maine

DRAINAGE AREA	496 square miles
SURFACE AREA	4200 acres
DAM	
Type	Masonry Gravity
Top Elevation	665.0 feet NGVD
Toe Elevation	640.0 feet NGVD
Total Length	218.5 feet
PRINCIPAL SPILLWAY	
Gates	Five Rollar Gates
Elevation	650.0 feet NGVD
Length	78.0 feet
EMERGENCY SPILLWAY	
Gates	Nine Vertical Lift Gates
Elevation	650.0 feet NGVD
Length	60.3 feet
OUTLETS	
Type	Sluice Gates
Number and Size	(4) 10 ft x 10 ft (1) 10 ft x 7 ft
Type	Vertical Lift Gates
Number and Size	(9) 5 ft high x 7 ft wide

V. HISTORICAL AND NEW OPERATING SCHEDULE

As stated previously, the objective of this study was to evaluate the spring and late summer/fall season downstream flood impacts of various drawdown scenarios for the Telos Dam and Matagamon Dam. Compared to historical operation, the MLA's new water management plan includes maintaining a fuller pond between 1 April and 1 May and July 15 and Labor Day, and setting a drawdown limit of 6 feet total (versus ±13 feet historically) to be achieved by October 15. A summary of the historical and new operating schedules is presented below.

Historical Operating Schedule.

- Lake Filled	15 April – 1 June
- High Storage Maintained	1 June – 1 August
- Drawdown	1 August – 1 October
- Low Storage Maintained	1 October – 15 April

- Telos Lake maximum pool stage 943.7 ft NGVD
- Telos Lake full drawdown pool stage 940.0 ft NGVD
- Grand Lake maximum pool stage 656.0 ft NGVD
- Grand Lake 8-foot drawdown pool stage 648.0 ft NGVD

New Operating Schedule.

- Lake Filled	1 April - 1 May
- Full Pond Maintained	1 May – July 15
- High Storage Maintained	15 July – Labor Day
- Drawdown	Labor Day – 15 October
- Low Storage Maintained	15 October – 31 March

- Telos Lake maximum pool stage 943.7 ft NGVD
- Telos Lake full drawdown pool stage 940.0 ft NGVD
- Grand Lake maximum pool stage 656.0 ft NGVD
- Grand Lake 8-foot drawdown pool stage 648.0 ft NGVD

VI. FLOOD HISTORY

A .General. Floods can occur any season of the year, and historically, most high flows have occurred as a result of high volume spring runoff due to snow melt in combination with heavy rainfall events, or high intensity coastal storms that ride up the Atlantic seaboard during late summer or fall. At least four severe spring floods have been experienced in the area during the 20th century, including the March 1936, April 1973, April 1979 and April 1987 flood events, which were the result of significant rain and snow melt. These spring events were analyzed in this study. In addition, three historical fall season storms, September 1999, September 1981 and November 1966 were also analyzed in this study. Details on each of the storm events are as follows:

Spring Storm Events:

B. March 1936. The peak flow recorded at Grindstone on the 20 March 1936 was 26,700 cfs. This storm resulted in frozen ground, deep snows and thick ice deposits coupled with heavy rainfall and 7.5-inch snow water equivalents left flood conditions comparable to the April 1987 flood. This storm was not modeled in this study due to lack of available rainfall data.

C. April 1973. Snowmelt and rain brought flooding to the Penobscot watershed on 29 April 1973. The peak flow recorded at Grindstone was 30, 600 cfs. This storm was not modeled in this study due to lack of available rainfall data.

D. April 1979. The 28 April 1979 flood brought peak flows at Grindstone of 24,900 cfs and was a result of snowmelt and 3.5 inches of rain recorded at the Matagamon Dam and 3.9 inches in Millinocket between 27-29 April (see Table 2). This storm was modeled in this study due to the availability of rainfall and flow discharge data for both the Matagamon Dam and Telos Dam.

Table 2
April 27-29, 1979 Storm Event
Hourly Rainfall Recorded at NWS Gage # 3250 Grand Lake Matagamon, Maine

Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)
27 Apr 1979	0800	0.1	28 Apr 1979	0200	0.1	28 Apr 1979	2000	0.1
27 Apr 1979	0900	0.0	28 Apr 1979	0300	0.2	28 Apr 1979	2100	0.1
27 Apr 1979	1000	0.1	28 Apr 1979	0400	0.2	28 Apr 1979	2200	0.2
27 Apr 1979	1100	0.0	28 Apr 1979	0500	0.3	28 Apr 1979	2300	0.1
27 Apr 1979	1200	0.0	28 Apr 1979	0600	0.1	28 Apr 1979	2400	0.2
27 Apr 1979	1300	0.1	28 Apr 1979	0700	0.0	29 Apr 1979	0100	0.1
27 Apr 1979	1400	0.0	28 Apr 1979	0800	0.0	29 Apr 1979	0200	0.1
27 Apr 1979	1500	0.0	28 Apr 1979	0900	0.0	29 Apr 1979	0300	0.0
27 Apr 1979	1600	0.1	28 Apr 1979	1000	0.0	29 Apr 1979	0400	0.1
27 Apr 1979	1700	0.0	28 Apr 1979	1100	0.0	29 Apr 1979	0500	0.0
27 Apr 1979	1800	0.1	28 Apr 1979	1200	0.0	29 Apr 1979	0600	0.0
27 Apr 1979	1900	0.1	28 Apr 1979	1300	0.1	29 Apr 1979	0700	0.0
27 Apr 1979	2000	0.1	28 Apr 1979	1400	0.0	29 Apr 1979	0800	0.1
27 Apr 1979	2100	0.1	28 Apr 1979	1500	0.0	29 Apr 1979	0900	0.1
27 Apr 1979	2200	0.2	28 Apr 1979	1600	0.1	29 Apr 1979	1000	0.1
27 Apr 1979	2300	0.1	28 Apr 1979	1700	0.0	29 Apr 1979	1100	0.0
27 Apr 1979	2400	0.2	28 Apr 1979	1800	0.1	29 Apr 1979	1200	0.1
28 Apr 1979	0100	0.1	28 Apr 1979	1900	0.1			

E. March/April 1987. A pair of spring storms occurring in March and April 1987 combined with snowmelt to produce major flooding in Maine. This storm event recorded approximately 4.2 inches of rain between 31 March and 1 April 1987 (table 3) with 5 to 6 inch snow water equivalents not uncommon. Flow discharge data is available at the USGS gage at Grindstone and the Matagamon Dam, only. The peak-recorded flow at

Grindstone was 27,000 cfs occurring on 31 March. Rainfall computed for this storm event was used to analyze various drawdown scenarios for the Matagamon Dam, see section VIII.E.3.

Table 3
March 31 – April 1, 1987 Storm Event
Hourly Rainfall Recorded at NWS Gage # 3250 Grand Lake Matagamon, Maine

Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)
31 Mar 1987	0900	0.10	01 Apr 1987	0500	0.00
31 Mar 1987	1000	0.00	01 Apr 1987	0600	0.00
31 Mar 1987	1100	0.10	01 Apr 1987	0700	0.00
31 Mar 1987	1200	0.10	01 Apr 1987	0800	0.00
31 Mar 1987	1300	0.20	01 Apr 1987	0900	0.10
31 Mar 1987	1400	0.20	01 Apr 1987	1000	0.00
31 Mar 1987	1500	0.00	01 Apr 1987	1100	0.10
31 Mar 1987	1600	0.10	01 Apr 1987	1200	0.10
31 Mar 1987	1700	0.10	01 Apr 1987	1300	0.20
31 Mar 1987	1800	0.10	01 Apr 1987	1400	0.20
31 Mar 1987	1900	0.10	01 Apr 1987	1500	0.00
31 Mar 1987	2000	0.20	01 Apr 1987	1600	0.10
31 Mar 1987	2100	0.10	01 Apr 1987	1700	0.10
31 Mar 1987	2200	0.30	01 Apr 1987	1800	0.10
31 Mar 1987	2300	0.20	01 Apr 1987	1900	0.10
31 Mar 1987	2400	0.10	01 Apr 1987	2000	0.20
01 Apr 1987	0100	0.10	01 Apr 1987	2100	0.10
01 Apr 1987	0200	0.10	01 Apr 1987	2200	0.30
01 Apr 1987	0300	0.00	01 Apr 1987	2300	0.20
01 Apr 1987	0400	0.00	01 Apr 1987	2400	0.10

Fall Storm Events:

F. November 1966. The November 1966 storm event was a result of a tropical airmass that traveled up the atlantic seaboard producing heavy rainfall across the eastern and midland areas of Maine between 2 and 3 November. Rain accumulations were variable ranging from approximately 6 inches at Millinocket, Maine (see Table 4) to approximately 2.0 inches at Telos Dam and less in the upper reaches of the watershed. Major damage from the flood included washouts of miles of highways and streets. Some small bridges were lost or damaged and numerous culverts were washed out. Damage to factories and warehouses were reported in Guilford, Dover-Foxcroft, Brownville and the Milo areas. Flow discharge data is not available at the Matagamon or Telos dams for this storm event. However, recorded discharge data is available at the U.S. Geological Survey (USGS) Gage at Grindstone, Maine. This gage recorded a peak flood flow of 22,800 cubic feet per second (cfs).

Table 4
November 3, 1966 Storm Event
Hourly Rainfall Recorded at NWS Gage # 5304 Millinocket, Maine

Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)
3 Nov 1966	0200	0.0	3 Nov 1966	1200	0.41
3 Nov 1966	0300	0.0	3 Nov 1966	1300	0.47
3 Nov 1966	0400	1.6	3 Nov 1966	1400	0.23
3 Nov 1966	0500	0.18	3 Nov 1966	1500	0.11
3 Nov 1966	0600	0.0	3 Nov 1966	1600	0.01
3 Nov 1966	0700	0.4	3 Nov 1966	1700	0.0
3 Nov 1966	0800	0.3	3 Nov 1966	1800	0.0
3 Nov 1966	0900	0.34	3 Nov 1966	1900	0.2
3 Nov 1966	1000	0.4	3 Nov 1966	2000	0.0
3 Nov 1966	1100	0.34	3 Nov 1966	2100	0.0

G. September 1981. The September 1981 storm event recorded approximately 7.5 inches of rain between 22 and 24 September (see Table 5). Flow discharge data is available at the USGS gage at Grindstone and the Matagamon Dam, only. The peak-recorded flow at Grindstone was 19,000 cfs occurring on 25 September.

Table 5
September 22-24, 1981 Storm Event
Hourly Rainfall Recorded at NWS Gage # 5304 Millinocket, Maine

Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)
22 Sept 1981	0800	0.0	23 Sept 1981	0400	0.0	23 Sept 1981	2400	0.0
22 Sept 1981	0900	0.1	23 Sept 1981	0500	0.1	24 Sept 1981	0100	0.0
22 Sept 1981	1000	0.0	23 Sept 1981	0600	0.0	24 Sept 1981	0200	0.4
22 Sept 1981	1100	0.1	23 Sept 1981	0700	0.1	24 Sept 1981	0300	0.5
22 Sept 1981	1200	0.1	23 Sept 1981	0800	0.0	24 Sept 1981	0400	0.6
22 Sept 1981	1300	0.2	23 Sept 1981	0900	0.0	24 Sept 1981	0500	0.4
22 Sept 1981	1400	0.1	23 Sept 1981	1000	0.0	24 Sept 1981	0600	0.0
22 Sept 1981	1500	0.0	23 Sept 1981	1100	0.0	24 Sept 1981	0700	0.1
22 Sept 1981	1600	0.1	23 Sept 1981	1200	0.1	24 Sept 1981	0800	0.2
22 Sept 1981	1700	0.2	23 Sept 1981	1300	0.4	24 Sept 1981	0900	0.2
22 Sept 1981	1800	0.1	23 Sept 1981	1400	0.3	24 Sept 1981	1000	0.3
22 Sept 1981	1900	0.1	23 Sept 1981	1500	0.0	24 Sept 1981	1100	0.4
22 Sept 1981	2000	0.0	23 Sept 1981	1600	0.1	24 Sept 1981	1200	0.3
22 Sept 1981	2100	0.0	23 Sept 1981	1700	0.1	24 Sept 1981	1300	0.2
22 Sept 1981	2200	0.1	23 Sept 1981	1800	0.1	24 Sept 1981	1400	0.3
22 Sept 1981	2300	0.1	23 Sept 1981	1900	0.1	24 Sept 1981	1500	0.2
22 Sept 1981	2400	0.0	23 Sept 1981	2000	0.0	24 Sept 1981	1600	0.1
23 Sept 1981	0100	0.1	23 Sept 1981	2100	0.1	24 Sept 1981	1700	0.2
23 Sept 1981	0200	0.0	23 Sept 1981	2200	0.1	24 Sept 1981	1800	0.1
23 Sept 1981	0300	0.0	23 Sept 1981	2300	0.0			

H. <u>September 1999</u>. The September 1999 storm event, which was classified as a tropical storm, recorded approximately 3.7 inches of rainfall at Millinocket, Maine between 16 and 17 September (see Table 6). Flow discharge data is available at the USGS gage at Grindstone on the East Branch Penobscot River, the USGS gage near Shin Pond on the Seboois River, and the Matagamon and Telos Dams for this storm event. The peak-recorded flow at Grindstone was 12,000 cfs occurring on 18 September.

Table 6
September 16-17, 1999 Storm Event
Hourly Rainfall Recorded at NWS Gage # 5304 Millinocket, Maine

Date	Time (hrs)	Rainfall (inches)	Date	Time (hrs)	Rainfall (inches)
16 Sept 1999	1800	0.1	17 Sept 1999	0400	0.1
16 Sept 1999	1900	0.0	17 Sept 1999	0500	0.1
16 Sept 1999	2000	0.1	17 Sept 1999	0600	0.0
16 Sept 1999	2100	0.3	17 Sept 1999	0700	0.0
16 Sept 1999	2200	0.5	17 Sept 1999	0800	0.1
16 Sept 1999	2300	0.6	17 Sept 1999	0900	0.0
16 Sept 1999	2400	0.3	17 Sept 1999	1000	0.1
17 Sept 1999	0100	0.5	17 Sept 1999	1100	0.0
17 Sept 1999	0200	0.4	17 Sept 1999	1200	0.1
17 Sept 1999	0300	0.2	17 Sept 1999	1300	0.1

VII. STREAMFLOW

The U.S. Geological Survey (USGS) has recorded flows of the East Branch Penobscot River at the USGS gage # 01029500 at Grindstone, Maine, from water year 1902 to 2000, see Table 7. The drainage area at this gage is 1086 square miles (sq. mi.). The analysis of these flow records was used to develop estimated flow characteristics of the East Branch Penobscot River.

Recorded flows at the USGS gage #01029200 near Shin Pond, Maine, beginning in water year 1998, provides flow information for the Seboeois River. This gage records runoff from a drainage area of 173 square miles, while the entire Seboeois River watershed has a drainage area 268 square miles, see Table 8. Analysis of the USGS gage flow near Shin Pond was used to develop unit hydrographs for the Seboeois River and adjacent hydrologically similar tributaries.

Peak discharge frequencies were developed for the East Branch Penobscot River by analysis of flow records at the USGS gaging station at Grindstone, Maine. The Corps of Engineers HEC-FFA (Flood Frequency Analysis) computer program was used to analyze the systematic record. The data was analyzed in a log Pearson Type III distribution, resulting in a mean log 4.1342, standard deviation of 0.1740, and an adopted skew of +0.1000 (regional skew). The resulting computed 1 percent chance (i.e. 100-year flood, or 1% chance of occurring in any given year) peak flow at the gage is 36,000 cfs, see Plate 7.

Table 7
East Branch Penobscot at Grindstone Peak Annual Streamflow
USGS Gage 01029500
Penobscot County, Maine

Water Year	Peak Annual Streamflow (cfs)	Water Year	Peak Annual Streamflow (cfs)	Water Year	Peak Annual Streamflow (cfs)
1903	10,900	1931	8,130	1959	9,450
1904	13,900	1932	16,600	1960	13,800
1905	7,780	1933	16,600	1961	17,100
1906	12,400	1934	14,900	1962	7,130
1907	18,200	1935	12,900	1963	15,200
1908	14,600	1936	26,900	1964	20,500
1909	24,400	1937	10,300	1965	4,220
1910	8,290	1938	9,860	1966	6,790
1911	9,820	1939	12,700	1967	22,800
1912	12,400	1940	23,700	1968	9,830
1913	16,700	1941	12,000	1969	15,300
1914	15,900	1942	12,700	1970	13,300
1915	10,200	1943	11,600	1971	18,200
1916	7,580	1944	13,900	1972	12,900
1917	18,600	1945	12,900	1973	30,600
1918	12,900	1946	12,900	1974	23,500
1919	10,800	1947	16,300	1975	12,800
1920	14,700	1948	12,600	1976	21,300
1921	13,200	1949	8,080	1977	13,100
1922	15,700	1950	13,900	1978	10,100
1923	33,700	1951	19,100	1979	24,900
1924	14,000	1952	11,400	1980	7,770
1925	6,020	1953	18,300	1981	19,000
1926	14,000	1954	17,700	1982	17,800
1927	10,500	1955	11,200	1987	27,000
1928	22,400	1956	7,860	1999	12,000
1929	15,200	1957	7,470	2000	19,800
1930	9,670	1958	24,800		

Table 8
East Branch Penobscot at Shin Pond Peak Annual Streamflow
USGS Gage 01029200
Penobscot County, Maine

Water Year	Peak Annual Streamflow (cfs)
1998	2540
1999	1760
2000	3100
2001	2250

VIII. METHODOLOGY

A. General. The COE hydrologic model (HEC-HMS) was used to evaluate flood conditions along the East Branch Penobscot River and release rates from the Telos and Matagamon Dams. USGS gage data recorded during the September 1999 storm event at Grindstone and Shin Pond were utilized to develop unit hydrographs for each of the six sub-basins presented in Plate 2 and Plate 3. Plate 4 presents a schematic of the East Branch Penobscot watershed with the downstream sub-basins combined. USGS data recorded during the September 1981 and November 1966 storm events at Grindstone were utilized to verify the HEC-HMS model. The calibrated and verified HEC-HMS model was then used to evaluate various drawdown scenarios, flow release rates from the Telos and Matagamon Dams and associated downstream flooding. Since the model was calibrated to a late summer/fall storm, the model was verified with fall storm events, September 1981 and November 1966. Evaluation of a spring storm event is presented below in Section VIII.E.

B. HEC-HMS Development.

1. General. The COE Hydrologic Engineering Center's – Hydrologic Modeling System (HEC-HMS) model was used to simulate reservoir storage routings and calculate overland stormwater runoff. Storage routings are based on the continuity equation (inflow=outflow + change in storage). Input for the model consisted of storage characteristics and unit hydrographs developed for the Telos/Chamberlain Lakes and the Grand Lakes and delineated drainage areas. The September 1999 storm event was used to calibrate the model since it had the greatest amount of recorded data.

2. September 1999 Storm Event Storage Routings. Storage-capacity-outflow relationships for the Telos and Matagamon dams were developed from release rates and pool stage elevations recorded at the dam during the 1999 storm event, see Table 10. The recorded Telos Dam and Matagamon Dam peak outflow rates during the 18 September 1999 flood event were 725 cfs and 2544 cfs, respectively. The storage-capacity-outflow relationships presented in Table 10 were used to develop and calibrate the HEC-HMS model, route the September 1999 storm event through the lakes and evaluate the drawdown scenarios discussed in Section VIII.F.2.

3. Unit Hydrograph (UH) Development. The September 1999 recorded streamflow and precipitation data was used to develop unit hydrographs for each of the six sub-basins presented in Plate 2 and Plate 3 and the combined downstream sub-basin presented in Plate 4. Unit hydrographs were developed and used as input for the HEC-HMS model. Six hour streamflow data recorded between 16-21 September 1999 at the Grindstone and Shin Pond USGS gages were used to compute the total flow produced from the three downstream sub-basins (417 sq. mi.), which includes Mud Brook (60 sq.mi.), Wassataquoik Stream (114 sq. mi.), and Localized flow (243 sq. mi.).

The drainage-area-ratio method was used to compute individual flow hydrographs and unit hydrographs for the three downstream sub-basins. The drainage-

area-ratio method computes the expected flow rate for a drainage basin with an unknown flow rate by applying a direct relationship to a drainage basin with similar topographic characteristics, known flow and regional coefficient. The regional coefficient utilized in this study was 0.7, which is an accepted coefficient for the topographic characteristics of the northeast. The drainage-area-ratio method was also used to compute the flow hydrographs and unit hydrographs for the two upstream sub-basins, Grand Lake and Allagash Lake.

4. UH and HEC-HMS Calibration. The computed unit hydrographs for each of the six sub-basins, the area-capacity properties for the Telos and Matagamon dams and hourly precipitation data for the 1999 storm event (see Table 6) were input into the HEC-HMS model. Rainfall runoff and routing computations were then performed to calibrate the model. As stated previously, the stage and release rates of both the Telos and Matagamon dams are known for the 1999 storm event, as well as the flow hydrographs for the Seboeois River and the East Branch Penobscot River at Grindstone. The flows computed by the model at the Matagamon Dam, Seboeois River and Grindstone were compared to the flows recorded during the September 1999 storm event.

The HEC-HMS model computed a peak flow of 11,555 cfs at Grindstone on the 18 September 1999 at 1200 hours. The USGS recorded peak flow at Grindstone on the 18 September 1999 was 12,000 cfs at approximately 1200 hours. The model computed the Seboeois River peak flow to be 1783 cfs on the 18 September 1999, which is similar to the 1760 cfs peak flow recorded at the USGS gage near Shin Pond (see Table 8). The model computed the peak outflow rate of the Telos Dam and Matagamon Dam to be 725 cfs and 2590 cfs, respectively. This also compares well to the recorded peak flows of 725 cfs and 2544 cfs, respectively. Therefore, the model, including unit hydrographs and the area-capacity parameters for the Telos Dam and Matagamon Dam, were considered calibrated. See Appendix A for the 1999 HEC-HMS peak flow results in tabular format. The September 1999 storm event computed flow hydrographs are presented in Plate 6 and Plate 7. See Section VIII.F.1 for further discussion of the flow hydrographs.

C. HEC-HMS Verification.

1. September 1981 Storm Event Storage Routings. Storage-capacity-outflow relationships for the Matagamon Dam were developed from release rates and pool stage elevations recorded during the 1981 storm event. The Telos Dam 1981 storm event release rates and pool stage elevations were developed from evaluating the 1999 storm event. Table 11 presents the 1981 adopted storage-capacity-outflow used in this study and is considered a reasonable representation of conditions based on past flood experience

The storage-capacity-outflow relationships presented in Table 11 were used to verify the HEC-HMS model and unit hydrographs by routing the September 1981 precipitation data (see Table 5) through the lakes and comparing the peak flow computed at Grindstone to the peak flow recorded at Grindstone. The model computed a peak flow

of 20,870 cfs at Grindstone on the 25 September 1981 at 1800 hours. The USGS recorded peak at Grindstone on the 25 September 1981 was 19,000 cfs at approximately 1800 hours. The model computed the peak outflow rate of the Matagamon Dam to be 7515 cfs. The recorded Matagamon Dam peak outflow rate during the September 1981 flood event was 8632 cfs. Outflow was not recorded at the Telos Dam during this storm event. Plate 8 presents the computed flow hydrographs for the 1981 storm event.

2. November 1966 Storm Event Storage Routings. Recorded release rates and pool stage elevations were not available for either the Telos Dam or Matagamon Dam for the 1966 storm event at the time of this study. Table 12 presents the adopted storage-capacity-outflow relationships of the Telos Dam and Matagamon Dam used in this study and is considered a reasonable representation of conditions based on past flood experience. The storage-capacity-outflow relationships were used to verify the HEC-HMS model and unit hydrographs by applying the November 1966 precipitation data (see Table 4) and routing them through the lakes and comparing the peak flow computed at Grindstone to the peak flow recorded at Grindstone. Although a total of 5 inches of rainfall was recorded at Millinocket for this storm event, only 2 inches fell at Telos and less in the upper reaches of the watershed. Therefore, the peak flows at Grindstone are indicative of the variable rainfall. The peak flow computed at Grindstone is also sensitive to the initial pool stage of the Chamberlain/Telos Lakes and the Grand Lakes. The model was run iteratively, adjusting the initial pool stages until the computed flow depicted the recorded peak flow at Grindstone. Based on this process, an initial pool stage of 942.0 feet NGVD and 652.0 feet NGVD for the Chamberlain/Telos Lakes and Grand Lakes, respectively, was computed.

The model computed a peak flow of 23,053 cfs at Grindstone on the 4 November 1966 at 2400 hours. The USGS recorded peak flow at Grindstone on the 4 November 1966 was 22,800 cfs at approximately 1200 hours. Therefore, the model, including unit hydrographs and the routing parameters for both the Telos/Chamberlain Lake and the Grand Lake, was considered calibrated and verified. See Appendix A for the 1999 HEC-HMS results in tabular format. Plate 9 presents the computed flow hydrographs for the 1966 storm event.

D. 100-year Storm Event (Fall Conditions). Table 9 presents the U.S. Weather Bureau Technical Paper No. 40 (TP-40) rainfall data. The Grand Lakes region 100-yr/24-hr rainfall depth is estimated to be 5.0 inches. This is less than the 6.0-inches recorded at Millinocket, Maine and greater than the 4.8-inches recorded near the Telos Dam during the 1966 storm event. The TP-40 100-yr rainfall was applied to the HEC-HMS model with storage routing parameters calibrated for the 1966 storm event. Table 14 presents the storage-capacity-outflow relationships of the Telos Dam and Matagamon Dam adopted for the 100-yr storm event. The TP-40 100-yr rainfall was routed using the adopted storage-capacity-outflow relationships.

The peak flow computed at Grindstone is sensitive to the initial pool stage of the Chamberlain/Telos Lakes and the Grand Lakes. Therefore, the 25-yr mean pool stage recorded on 1 September was used to compute the 100-yr flow under existing conditions.

The 1955 to 1979 Grand Lake Dam Operating Chart recorded the 25-yr mean pool elevation to be 652.0-feet NGVD on 1 September. The mean elevation at Telos Dam on 1 September is 942.0-feet NGVD.

The computed flows for the 100-yr storm event are presented in Table 15. As shown in the table, the 100-yr flow released from the Matagamon Dam is 12,010 cfs and the 100-yr flow computed at Grindstone is 35,325 cfs with 25-yr mean pool stages at the Telos and Matagamon Dams. See Appendix A for the 100-yr storm event HEC-HMS results in tabular format. Plate 10 presents the computed flow hydrographs for the 100-yr storm event.

E. Spring Storm Analysis . The peak flows recorded at Grindstone during a spring storm event are expected to follow the same characteristics as those of a fall event with the majority of flows generated in the downstream sub-basins. A significant flood event occurred as a result of heavy rainfall and snowmelt on 1 April 1987. Historical data for the Matagamon Dam was not available at the time of this analysis therefore, the 29 April 1979 flood event was used to generate the unit hydrograph and calibrate the HEC-HMS for a spring storm. Since the 1987 storm characteristics are similar to the 1979, the 1987 rainfall was applied through the calibrated model to conduct the drawdown analysis.

On 28 April 1979 the recorded peak flow at Grindstone was 24,500 cfs while the Matagamon Dam flow peaked on 1 May with 8045 cfs. The 28 April 1979 event was the result of 3.5 inches of rainfall at the Matagamon Dam while the 1 April 1987 event had 4.2 inches of rainfall. The average snow water equivalent for Bangor, Maine in March is 3.44 inches while that in April is 3.32 inches. This study computed the theoretical snow water equivalent for the 28 April 1979 flood to be 3.4 inches with 3.5 inches of rainfall. Snow water equivalents for the 1 April 1987 were reported between 5-6 inches with 4.2 inches of rainfall.

Storage-capacity-outflow relationships for the Telos and Matagamon dams were developed from release rates and pool stage elevations recorded at the dam during the 1979 flood event. Table 13 presents the adopted storage-capacity-outflow relationships of the Telos and Matagamon dams developed for this event. The recorded Telos Dam and Matagamon Dam peak outflow rates for this event were 8044 cfs and 1810 cfs, respectively. The relationships presented in Table 13 were used to route the April 1979 rainfall through the lakes and evaluate the drawdown scenarios indicative of spring conditions (see Section VIII.F.2.a).

F. Flood and Drawdown Analysis.

1. General. The HEC-HMS model was used to simulate reservoir storage routings and calculate overland stormwater runoff for the East Branch Penobscot River watershed. The HEC-HMS model was calibrated to the September 1999 storm event and verified to the September 1981 and November 1966 storm events.

The steep topography associated with the Mud Brook, Wassataquoik Stream, and localized flow sub-basins generate high flows for high frequency storm events. The Seboois River contains natural attenuation at its upstream reaches; however, its flow hydrograph is synchronized with the three other downstream sub-basins, therefore, contributing to flooding along the East Branch Penobscot River at Grindstone.

Plate 6 through Plate 10 present the flood hydrographs for the 1999, 1981, and 1966 storm events, respectively. The downstream sub-basins comprise about 54% of the total drainage area, and yet, the flows generated by the downstream sub-basins during the 1999 storm event (depicted by the dashed curve on Plate 7) comprise approximately 87 percent of the peak flow recorded at Grindstone. This is due to the storage of the upstream lakes and dams and the downstream sub-basin peak flows being synchronized. The hydrographs also show the downstream sub-basins peak first, at nearly the same time as the peak flow at Grindstone, followed by the outflow from the Matagamon Dam. Plate 8 and Plate 9 present the September 1981 and November 1966 hydrographs. These hydrographs also depict a total flow generated by the downstream sub-basins that comprises about 77% of the peak flow recorded at Grindstone. The time-to-peak discharge of the Matagamon Dam occurred approximately 39 hours after the downstream sub-basins and the USGS gage at Grindstone.

2. Fall Conditions Drawdown Analysis. Section V of this study discusses the existing and proposed operating and drawdown schedule for the Telos/Chamberlain Lakes and the Grand Lakes. The MLA has proposed to extend the period of recreational storage from 15 July to Labor Day (2-9 September), therefore extending the recreational boating season on the lake. However, coastal storms occasionally travel up the Atlantic seaboard during late summer and fall, potentially bringing intense rainfall and flooding to the East Branch Penobscot River watershed. The intent of this study was to evaluate the Chamberlain/Telos Lakes and Grand Lakes pool stages and drawdown scenarios during the 100-yr storm event to determine if extending the recreational pool stages until labor day increases flooding along the East Branch Penobscot River.

The calibrated HEC-HMS model was used to evaluate various drawdown scenarios for the Telos/Chamberlain Lakes and the Grand Lakes. The drawdown scenarios at the Matagamon Dam include a 2-foot drawdown, 4-foot drawdown, 6-foot drawdown, and an 8-foot drawdown. The drawdown of the Telos Dam included a 0.7-foot, 1.7-foot, 2.7-foot and a 3.7 foot drawdown ranging between elevation 943.7-foot NGVD and 940.0-feet NGVD. Each drawdown scenario was evaluated for the 100-yr storm event. Table 12 presents the computed peak flow released from the Matagamon Dam and the flows at Grindstone for various drawdown scenarios of the Chamberlain/Telos Lakes and Grand Lake.

Historically, drawdown of the Grand Lake began on 1 August and full drawdown (13' or to elev 643 NVGD for Grand Lake) of both lakes was achieved by 1 October. The MLA has proposed to extend the period of maximum storage in the lakes from 1 August until Labor Day (2-9 September), and then achieve full drawdown pool stages by 15 October. The existing mean pool stage of the lakes on 1 September is

approximately 652.0-feet NGVD and 942.0-feet NGVD for the Grand Lakes and Telos/Chamberlain Lakes, respectively. As presented on Table 15, this results in 12,010 cfs released from the Matagamon Dam and 35,325 cfs of flow at Grindstone under these conditions.

The maximum pool stages of 656.0-feet NGVD and 943.7-feet NGVD at the Matagmon Dam and the Telos Dam, respectively, will result in 12,540 cfs released from the Matagamon Dam and 37,120 cfs at Grindstone if a 100-yr storm event were to occur under these conditions. This is a minimal increase in flow compared to those computed under the existing mean pool stage conditions. Therefore, extending the maximum pool stage of the Grand Lake from 15 July to Labor Day (2-9 September) will not significantly increase flooding along the East Branch Penobscot River including the Matagamon Dam campground, Muriel Fortier's Campground or Bowlin Sport Camps.

Under full drawdown conditions of 648-feet NGVD and 940-feet NGVD for the Matagamon Dam and Telos Dam, respectively, flows released from the Matagamon Dam will be reduced from 12,540 cfs to 7,830 cfs, or 38%, while the computed flows at Grindstone are reduced from 37,120 cfs to 26,030 cfs, or 30%, if a 100-yr storm event were to occur under these conditions.

3. Spring Conditions Drawdown Analysis. Section V of this study discusses the existing and proposed operating and drawdown schedule for the Telos/Chamberlain Lakes and the Grand Lakes. The MLA has proposed to fill the lake between 1 April and 1 May as opposed to 15 April and 1 June. Raising the WSE of the Grand Lake earlier in the spring season could pose a flood threat if intense rainfall occurs during the snowmelt season. The intent of this analysis was to evaluate the Chamberlain/Telos Lakes and Grand Lakes pool stages and drawdown scenarios during an extreme memorable flood (April 1987) to determine if raising the pool stage early in the spring season increases flooding along the East Branch Penobscot River.

Since historic flow data (April 1987) for the Matagamon Dam was not available at the time of this analysis, the April 1979 flood was used to calibrate the HEC-HMS model for spring flood conditions. The model was then used to evaluate various drawdown scenarios for the Telos/Chamberlain Lakes and the Grand Lakes using the 1 April 1987 rainfall (see Section VIII.E). The drawdown scenarios at the Matagamon Dam include a 2-foot drawdown, 4-foot drawdown, 6-foot drawdown, and an 8-foot drawdown. The drawdown of the Telos Dam included a 0.7-foot, 1.7-foot, 2.7-foot and a 3.7 foot drawdown ranging between elevation 943.7-foot NGVD and 940.0-feet NGVD. Table 17 presents the computed peak flow released from the Matagamon Dam and the flows at Grindstone for various drawdown scenarios of the Chamberlain/Telos Lakes and Grand Lake.

As presented in Table 16, the maximum pool stages of 656.0-feet NGVD and 943.7-feet NGVD at the Matagmon Dam and the Telos Dam, respectively, will result in 15,000 cfs released from the Matagamon Dam and 32,850 cfs at Grindstone if an extreme spring storm similar to the April 1987 event occurs. In order to reduce flows at

the dam to normal spring discharge, the pool stage of the Grand Lakes would need to be lowered considerably. Therefore, raising the pool stage early in the spring season will significantly increase flows along the East Branch Penobscot River.

Under full drawdown conditions of 648-feet NGVD and 940-feet NGVD for the Matagamon Dam and Telos Dam, respectively, flows released from the Matagamon Dam will be reduced from 15,000 cfs to 4,950 cfs, or 67%, while the computed flows at Grindstone are reduced from 32,850 cfs to 22,200 cfs, or 32%, if a 100-yr storm event were to occur under these conditions.

G. HEC-RAS Analysis – Spring Flood Conditions. The COE Hydrologic Engineering Center's River Analysis System model, HEC-RAS, was used to evaluate flood elevations at Fortier's Camp located approximately 2 miles downstream of the Matagamon Dam by applying 1987 rainfall and snowmelt conditions. The camp is located in the flood plain adjacent to the river. A cross-section of the river was surveyed 74 feet downstream of the camp. The cross-section elevations are based on an arbitrary datum with the ground of the camp at elevation 95.2 feet, the first floor of the camp at 97.7 feet and the dirt road near the camp at elevation 95.0 feet. According to the camp owner, the flood elevation rose to 6-inches over the first floor, or an elevation of 98.2 feet during the 1987 flood.

As presented in Table 17, the HEC-RAS model computed the river elevation for several flows including 1000 cfs, 3000 cfs, 5000 cfs, 7000 cfs, 9000 cfs, 11,000 cfs, 13,000 cfs and 15,000 cfs. According to the dam operator, spring flow releases typically reach 7,000 cfs, which causes minor flooding to the camp and road. The results of this analysis computed a WSE of 95.0 ft with a typical spring flow of 7,000 cfs and a WSE of 98 feet for a flow of 13,000 cfs. These elevations agree with flood information provided from the dam operator and the owner of Fortier's Camp. Therefore, in order for flood levels to peak below the camp first floor elevation of 97.7 feet, the East Branch Penobscot River flows released from the Matagamon Dam need to remain below 12,000 cfs (Table 17), which correlates to a drawdown scenario of the Matagamon Dam at elevation 652.0 feet NGVD and the Telos Dam at elevation 943.0 feet NGVD (Table 16).

IX. SUMMARY AND DISCUSSION

In January of 2001, the newly formed Matagamon Lake Association (MLA), comprised of camp owner, tribal, and resource agency representatives, acquired ownership of the Grand Lake Matagamon Dam. The MLA has since adopted a new water management regime for the Grand Lake/Matagamon Dam segment of the system, which prioritizes fish and wildlife enhancement and essential flood control measures over the historical operational priority of providing storage for downstream hydropower generation.

The PIN, on behalf of MLA of which PIN is a member, has expressed concerns regarding changes in the timing and degree of annual drawdowns at Grand Lake, resulting from new fish and wildlife management goals in the watershed, and the

potential for increased flooding impacts to properties along the East Branch Penobscot River downstream of the dam. The intent of this study was to evaluate the Chamberlain/Telos Lakes and Grand Lakes pool stages and drawdown scenarios during documented spring and fall runoff events as well as a projected 100-yr storm event to determine if proposed changes in timing and magnitude of draw down at Grand Lake Matagamon increases flooding along the East Branch Penobscot River.

The COE hydrologic model, HEC-HMS, was developed to evaluate flood conditions along the East Branch Penobscot River for both fall and spring conditions. USGS gage data recorded during the September 1999, September 1981, and November 1966 storm events at Grindstone, Maine and Shin Pond, Maine were utilized to develop the model to represent fall conditions. First, unit hydrographs and area-capacity properties for the Telos and Matagamon Dams were adopted for the September 1999 storm event to calibrate the model for the fall event. Area-capacity properties for the September 1981 and November 1966 storm events were then adopted for the Telos and Matagamon Dams to verify the model for a fall event.

The hydrologic flood analysis conducted in this study for fall conditions generated hydrographs that determined the peak flows generated by the downstream sub-basins during the 1999, 1981 and 1966 storm events. The downstream sub-basin hydrographs are synchronized, generating a total flow that is the primary contribution to recorded peak flows at Grindstone. The 1999, 1981 and 1966 hydrographs determined that the downstream sub-basins and recorded peak flow at Grindstone peaked prior to the outflow from the Matagamon Dam. Since the time-to-peak discharge of the Matagamon Dam was not synchronized with the USGS gage at Grindstone, and the downstream sub-basins produced high flows that were synchronized at Grindstone, flow released from the dam was determined not the primary contribution to recorded peak flows at Grindstone.

Although flow released from the Matagamon Dam was determined not the primary contributor to recorded peak flows at Grindstone; flow released from the dam during a 100-yr storm event is considerable. Therefore, the calibrated HEC-HMS model was used to evaluate various drawdown scenarios for the 100-yr storm event. The drawdown analysis determined that extending the maximum pool stages of the Matagamon Dam and Telos Dam from 15 July until Labor Day (2-9 September) minimally increases the peak flood flows along the East Branch Penobscot River and at Grindstone.

USGS gage data recorded during the April 1979 and April 1987 storm events at Grindstone, Maine were utilized to develop the model to represent spring conditions. Since historic flow data during the April 1987 flood for the Matagamon Dam was not available at the time of this analysis, the April 1979 flood was used to calibrate the HEC-HMS model for spring flood conditions. The model was then used to evaluate various drawdown scenarios for the Telos/Chamberlain Lakes and the Grand Lakes using the 1 April 1987 rainfall. Table 16 presents the computed peak flow released from the Matagamon Dam and the flows at Grindstone for various drawdown scenarios of the Chamberlain/Telos Lakes and Grand Lake.

The maximum pool stages of 656.0-feet NGVD and 943.7-feet NGVD at the Matagmon Dam and the Telos Dam, respectively, will result in 15,000 cfs released from the Matagamon Dam and 32,850 cfs at Grindstone if an extreme spring storm similar to the April 1987 event occurs. In order to reduce flows at the dam to normal spring discharge (7000 cfs or less), the pool stage of the Grand Lakes would need to be lowered to 943.0 feet NGVD and 650 feet NGVD for the Telos and Matagamon Dams, respectively. In order to maintain flood levels below the Fortier's camp first floor elevation of 97.7 feet, the East Branch Penobscot River flows released from the Matagamon Dam need to be below 12,000 cfs (Table 17), which correlates to a drawdown scenario of the Matagamon Dam at elevation 652.0 feet NGVD and the Telos Dam at elevation 943.0 feet NGVD (Table 16). Therefore, filling the Grand Lake earlier in the spring season from 1 June to 1 May will increase flooding downstream of the Grand Lakes including the Matagamon Dam campground, Muriel Fortier's Campground or Bowlin Sport Camps by approximately 3 feet above normal spring flood levels.

Table 9
U.S. Weather Bureau Technical Paper No. 40 (TP-40) Data
(Rainfall Depth in Inches)

Time (hrs)	100-yr/24-hr Rainfall Depth in Inches (Grand Lakes Region)
1	2.0
2	2.5
3	3.0
6	3.5
12	4.5
24	5.0

Table 10
Matagamon and Telos Dams
September 1999 Storm Event Recorded Storage-Capacity-Outflow Properties

Matagamon Dam			Telos Dam		
Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)	Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
644.0	0	0	935.0	0	0
645.0	4200	40	936.0	0	0
645.6	6720	60	937.0	0	0
646.0	8400	80	938.0	11478	0
647.0	12600	120	939.0	22957	20
648.0	16800	160	940.0	36731	40
649.0	21000	200	941.0	48209	60
650.0	25200	240	942.0**	61983	80
651.0	29400	280	943.0	73462	84
652.0	33600	320	943.1	75757	706
653.0	37800	340	943.3	78053	725*
654.3**	42000	345	944.0	89532	725
654.6	43260	504	945.0	101010	1200
655.9	49980	2240			
656.0	50400	2544*			

* Peak outflow rates recorded at the Matagamon Dam and Telos Dam during the September 1999 storm event.
** Matagamon Dam and Telos Dam initial pool stage of the September 1999 storm event.

Table 11
Matagamon and Telos Dams
1981 Storm Event Adopted Storage-Capacity-Outflow Properties

Matagamon Dam			Telos Dam		
Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)	Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
644.0	0	0	935.0	0	0
645.0	4200	200	936.0	0	0
645.6	6720	340	937.0	0	0
646.0	8400	350	938.0	11478	0
647.0	12600	375	939.0	22957	20
648.0	16800	385	940.0	36731	40
649.0	21000	400	941.0	48209	60
650.0	25200	425	942.0	61983	80
651.0	29400	450	943.0	73462	84
652.4**	33600	500	943.1	75757	4500
653.0	37800	585	943.3	78053	5000
656.0	51000	8632	944.0	89532	5500
656.1	52000	8632*	945.0	101010	6000

* Peak outflow rate recorded at the Matagamon Dam during the September 1981 storm event.
** Matagamon dam initial pool stage at the start of the September 1981 storm event.
***(The September 1981 storm event recorded outflow rates and pool stage for the Telos Dam were unavailable at the time of this study, the values shown were computed.)

Table 12
Matagamon and Telos Dams
1966 Adopted Storm Event Storage-Capacity-Outflow Properties

Matagamon Dam			Telos Dam***		
Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)	Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
644.0	0	0	935.0	0	0
645.0	4200	200	936.0	0	0
646.0	8400	350	937.0	0	0
647.0	12600	375	938.0	11478	0
648.0	16800	385	939.0	22957	20
649.0	21000	400	940.0	36731	40
650.0	25200	425	941.0	48209	60
651.0	29400	450	942.0	61983	100
652.0	33600	500	943.0	73462	725
653.0	37800	3000	943.1	75462	1000
654.0	42000	3000	944.0	89532	5000
655.0	46200	5000	945.0	101010	5500
656.0	50400	9000			

*(September 1966 storm event recorded outflow rates for both the Matagamon Dam and the Telos Dam were unavailable at the time of this study, the values shown were computed.)

Table 13
Matagamon and Telos Dams
1979 Adopted Storm Event Storage-Capacity-Outflow Properties

Matagamon Dam			Telos Dam***		
Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)	Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
648.0	16800	2000	938.0	11478	750
650.0	25200	2500	940.0	36731	900
652.2	35000	2944	941.3	51653	1248
653.1	37800	3056	942.2	64852	1503
654.7	43260	3312	942.5	67723	1640
655.5	46620	7246	942.8	70592	1705
655.8	50000	8045	943.0	73462	1746
656.0	50400	15000	944.0	89532	2000

Table 14
Matagamon and Telos Dams
100-Yr Adopted Storm Event Storage-Capacity-Outflow Properties
(Without Snowmelt)

Matagamon Dam			Telos Dam		
Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)	Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
644.0	0	0	935.0	0	0
645.0	4200	200	936.0	0	0
645.6	6720	340	937.0	0	0
646.0	8400	350	938.0	11478	0
647.0	12600	375	939.0	22957	20
648.0	16800	385	940.0	36731	40
649.0	21000	400	941.0	48209	60
650.0	25200	425	942.0	61983	80.3
651.0	29400	450	943.0	73462	84
652.0	33600	570	943.1	75757	4500
653.0	37800	585	943.3	78053	5000
656.0	51000	12500	944.0	89532	5500
656.1	51500	13000	945.0	101010	6000

*(September 1966 storm event recorded outflow rates for both the Matagamon Dam and the Telos Dam were unavailable at the time of this study, the values shown were computed.)

Table 15
100-Yr Storm Event Computed Discharge (Fall Conditions)
at Matagamon Dam and Grindstone, cfs

Computed Matagamon Dam Discharge, cfs				
Matagamon Dam Drawdown	Telos Dam Elevation (ft, NGVD)			
	943.7	943.0	942.0	940.0
656.0 (Max. Pool)	12,540	12,500	12,500	12,500
654.0 (2-ft drawdown)	12,530	12,470	12,130	9,680
652.0 (4-ft drawdown)	12,510	12,380	12,010	9,560
650.0 (6-ft drawdown)	12,450	12,190	11,650	9,140
648.0 (8-ft drawdown)	12,280	11,790	10,880	7,830
Computed Discharge at Grindstone, cfs				
Matagamon Dam Drawdown	Telos Dam Elevation (ft, NGVD)			
	943.7	943.0	942.0	940.0
656.0 (Max. Pool)	37,120	36,940	35,940	32,160
654.0 (2-ft drawdown)	37,080	36,900	35,910	32,130
652.0 (4-ft drawdown)	37,020	36,600	35,325	31,530
650.0 (6-ft drawdown)	36,850	35,770	33,610	29,510
648.0 (8-ft drawdown)	36,160	33,820	30,080	26,030

	Proposed recreational pool stages through 1 September.
	Existing operating conditions with 25-yr mean pool elevations on 1 September.
	Existing and Proposed full drawdown pool stages by 15 October.

Table 16
Spring Flood Drawdown Analysis Computed Flows
at Matagamon Dam and Grindstone, cfs

Computed Matagamon Dam Discharge, cfs				
Matagamon Dam Drawdown	Telos Dam Elevation (ft, NGVD)			
	943.7	943.0	942.0	940.0
656.0 (Max. Pool)	15,000	15,000	15,000	15,000
654.0 (2-ft drawdown)	14,600	14,260	12,190	11.730
652.0 (4-ft drawdown)	13,280	12,190	12,620	11,250
650.0 (6-ft drawdown)	11,120	8,460	7,930	7,610
648.0 (8-ft drawdown)	7,390	7,300	6,940	4,950
Computed Discharge at Grindstone, cfs				
Matagamon Dam Drawdown	Telos Dam Elevation (ft, NGVD)			
	943.7	943.0	942.0	940.0
656.0 (Max. Pool)	32,850	31,380	30,930	30,150
654.0 (2-ft drawdown)	32,740	32,430	30,310	29,760
652.0 (4-ft drawdown)	31,310	30,230	30,470	28,840
650.0 (6-ft drawdown)	28,370	25,710	25,330	25,000
648.0 (8-ft drawdown)	24,640	24,550	24,190	22,200

Table 17
HEC-RAS Results
Computed WSE at Fortier's Camp for Spring Flows

Flow, cfs	WSE, feet
1000	91.0
3000	93.0
5000	94.0
7000	95.0
9000	96.0
11000	97.0
13000	98.0
15000	98.2

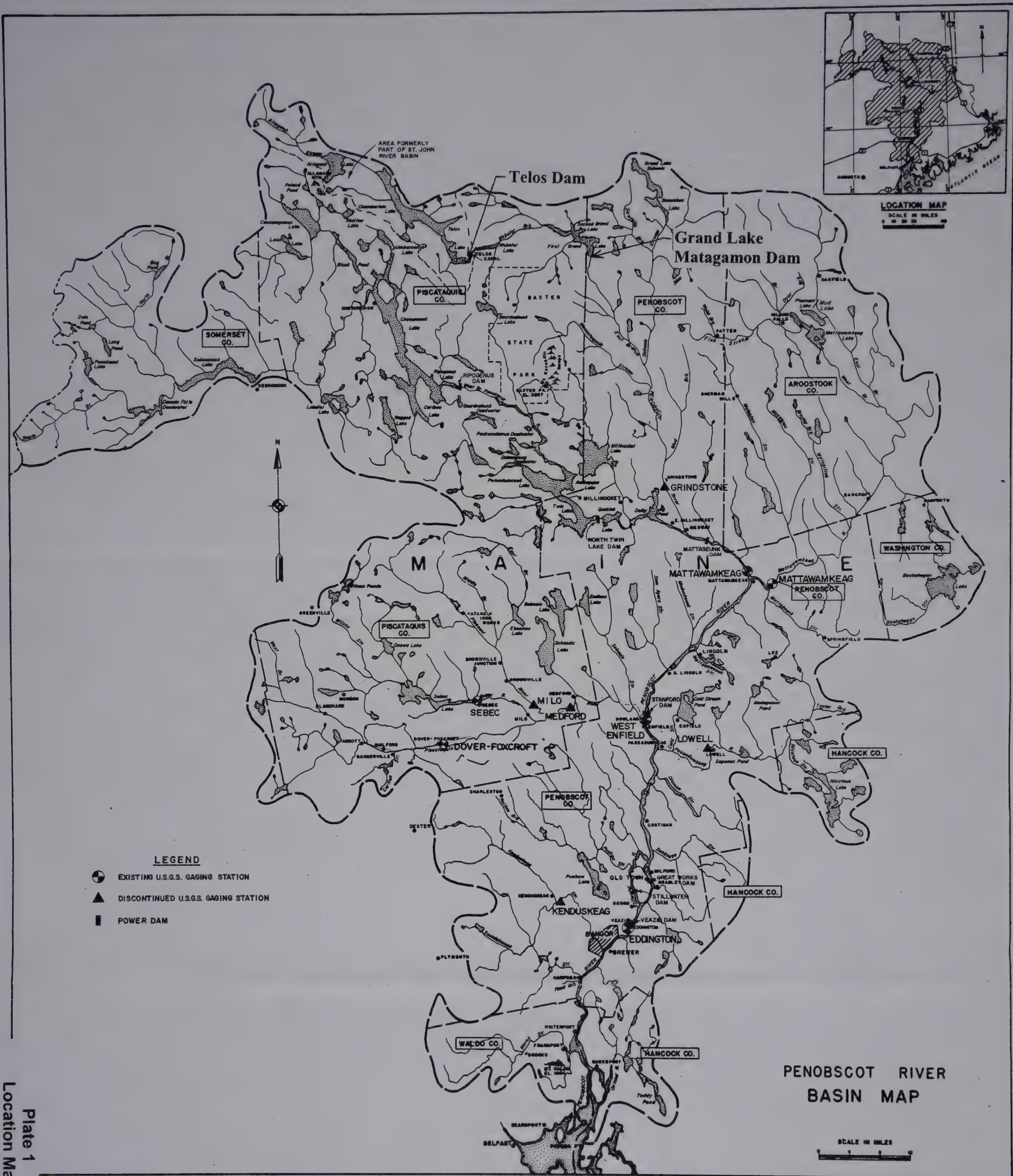


Plate 1
Location Map
Penobscot River, Maine

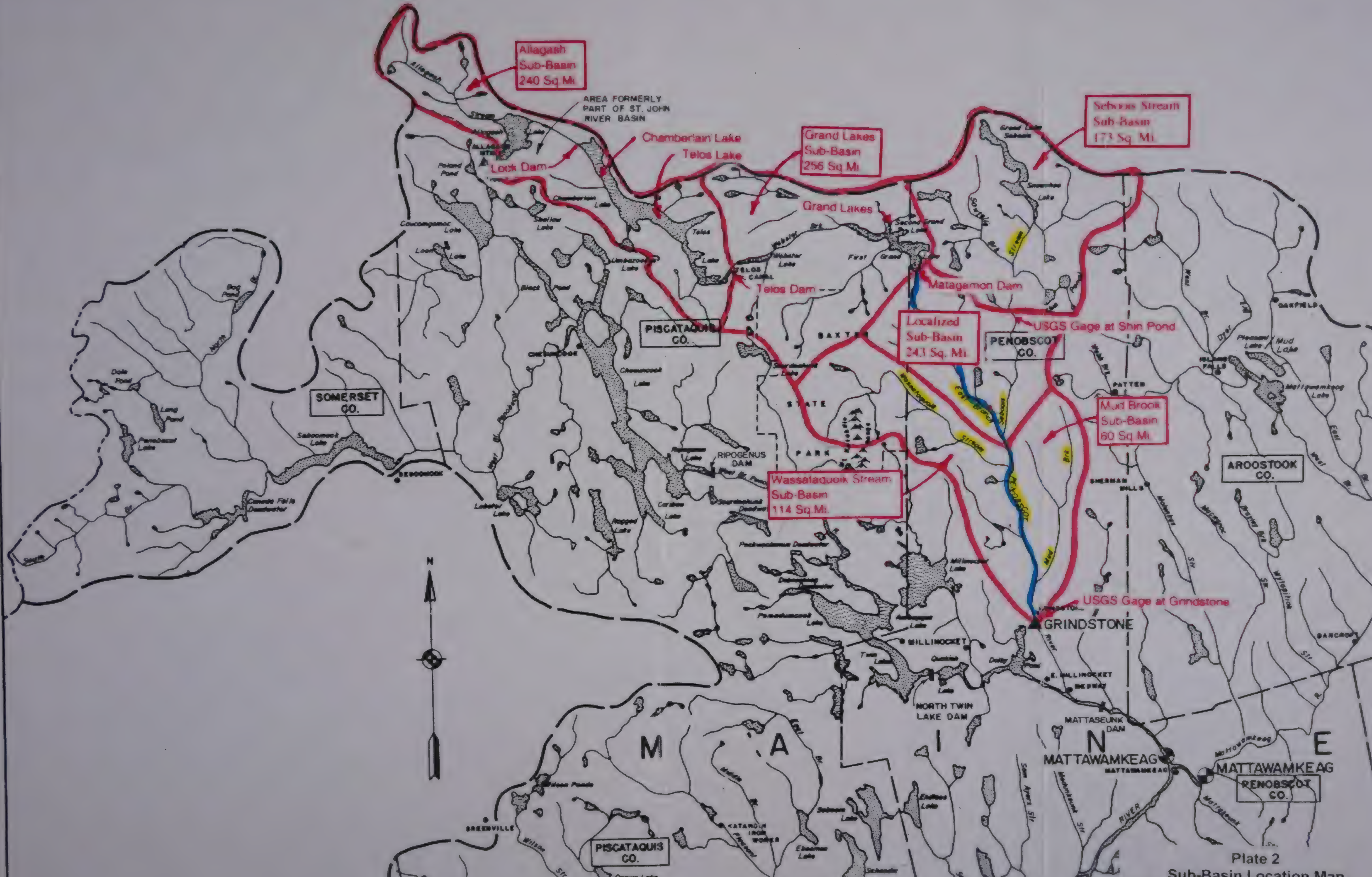


Plate 2
Sub-Basin Location Map
East Branch Penobscot River, Maine

Plate 3
HEC-HMS Individual Sub-Basin Schematic
East Branch Penobscot River, Maine

Plate 4
HEC-HMS Combined Sub-Basin Schematic
East Branch Penobscot River, Maine

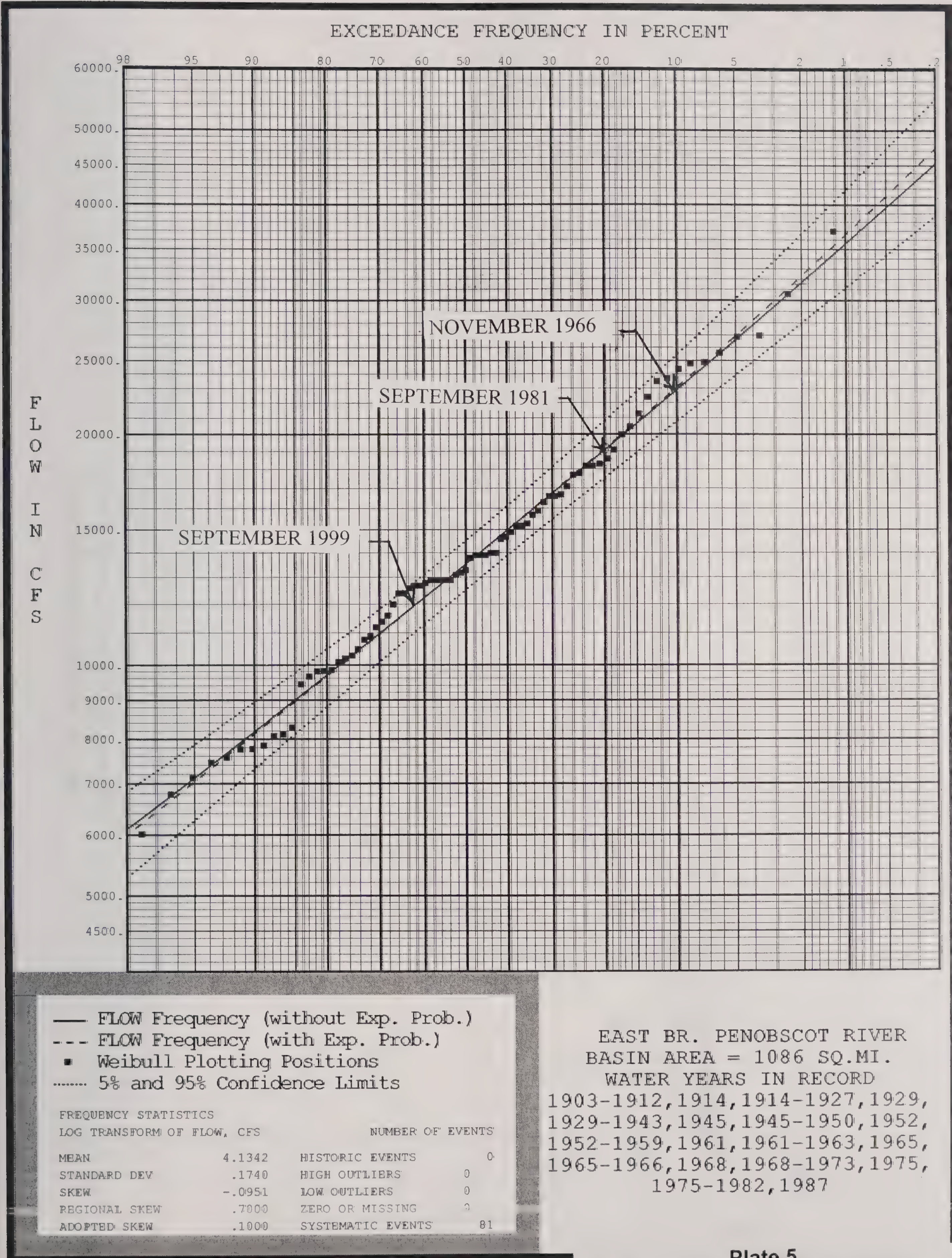


Plate 5
Discharge Frequency Curve
East Branch Penobscot River, Maine

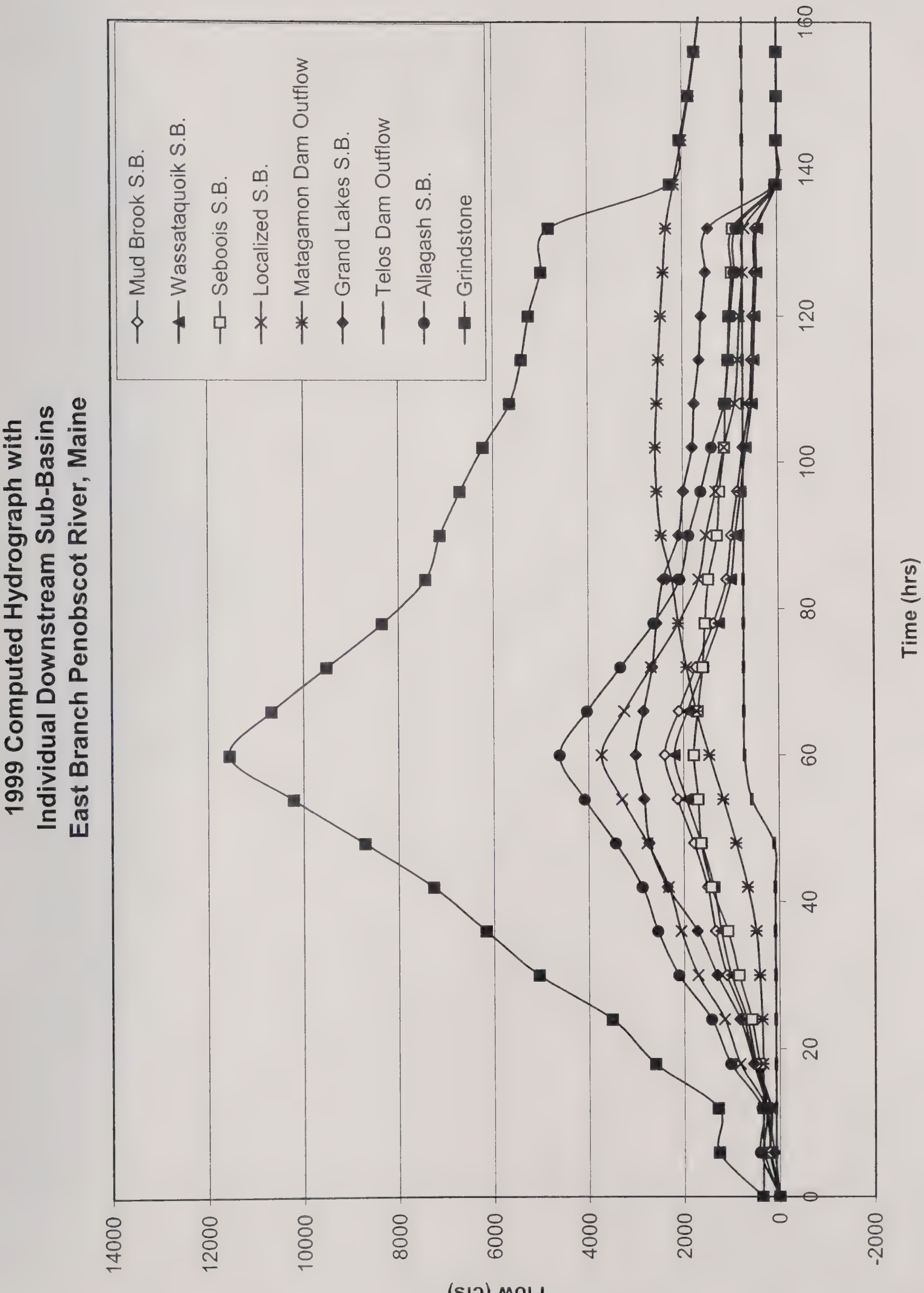


Plate 6
1999 Computed Hydrographic with Individual Downstream Sub-Basins East Branch Penobscot River, Maine

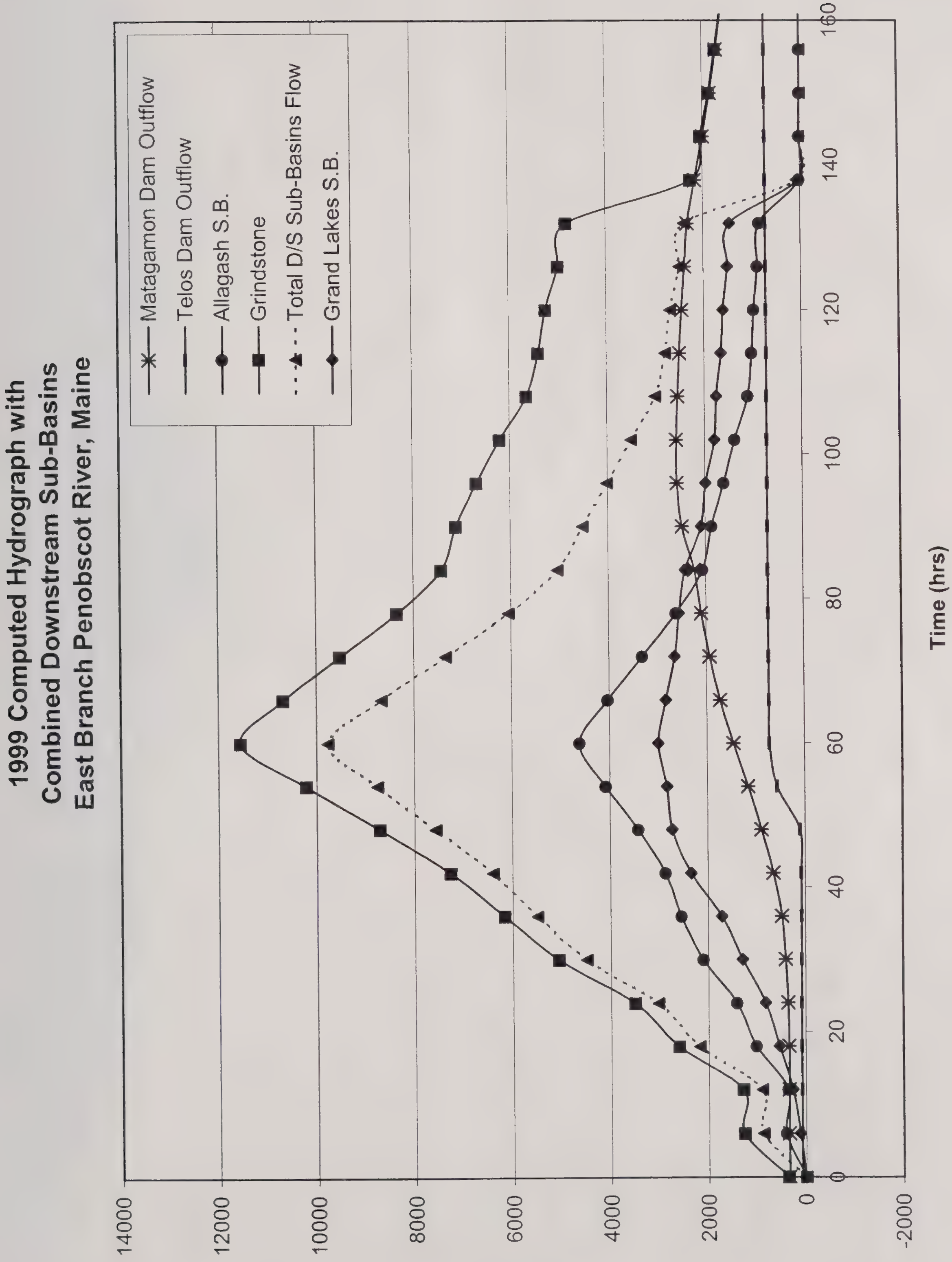


Plate 7
1999 Computed Hydrographic with
Combined Downstream Sub-Basins
East Branch Penobscot River, Maine

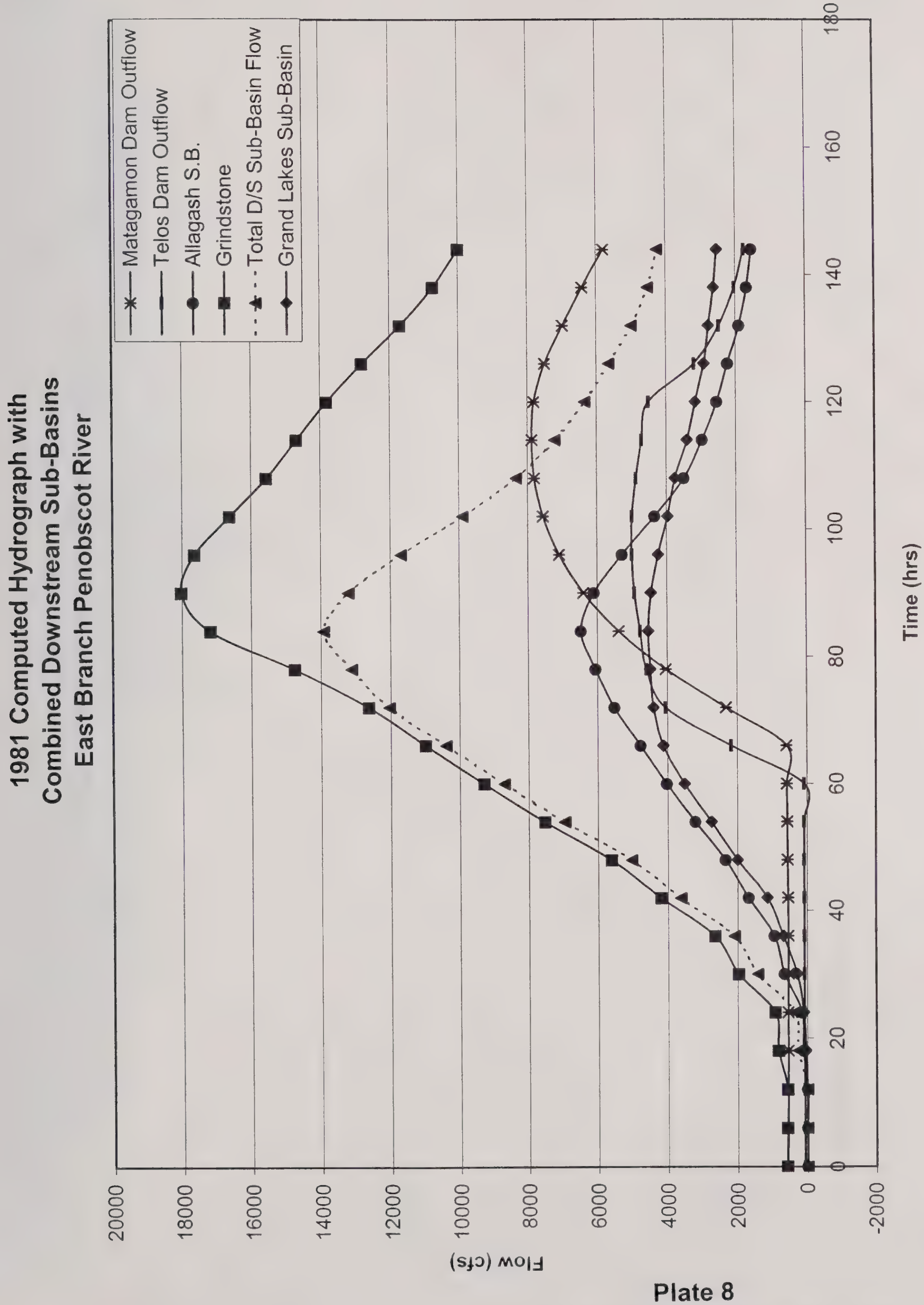


Plate 8
1981 Computed Hydrographic with
Combined Downstream Sub-Basins
East Branch Penobscot River, Maine

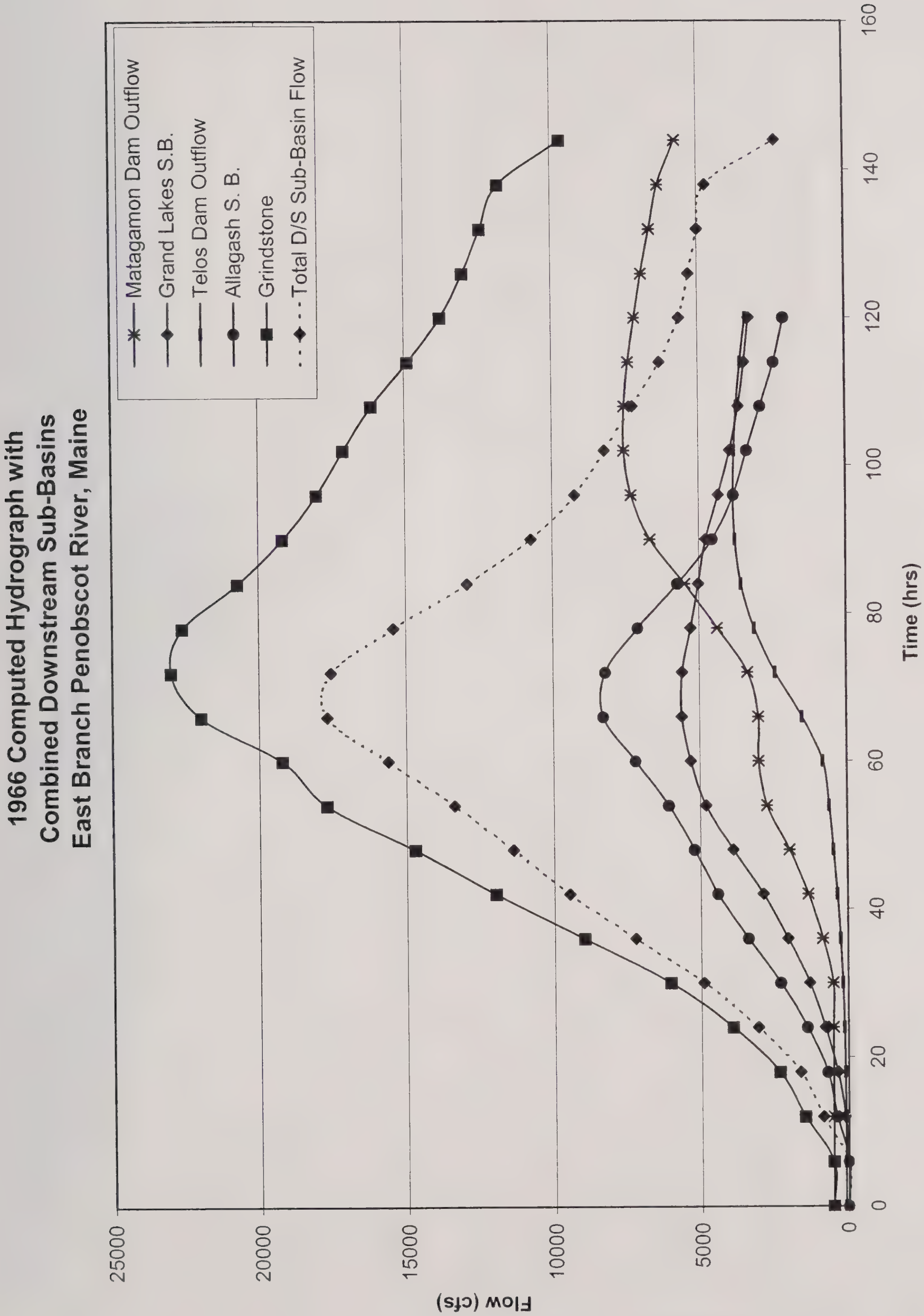


Plate 9
1966 Computed Hydrographic with
Combined Downstream Sub-Basins
East Branch Penobscot River, Maine

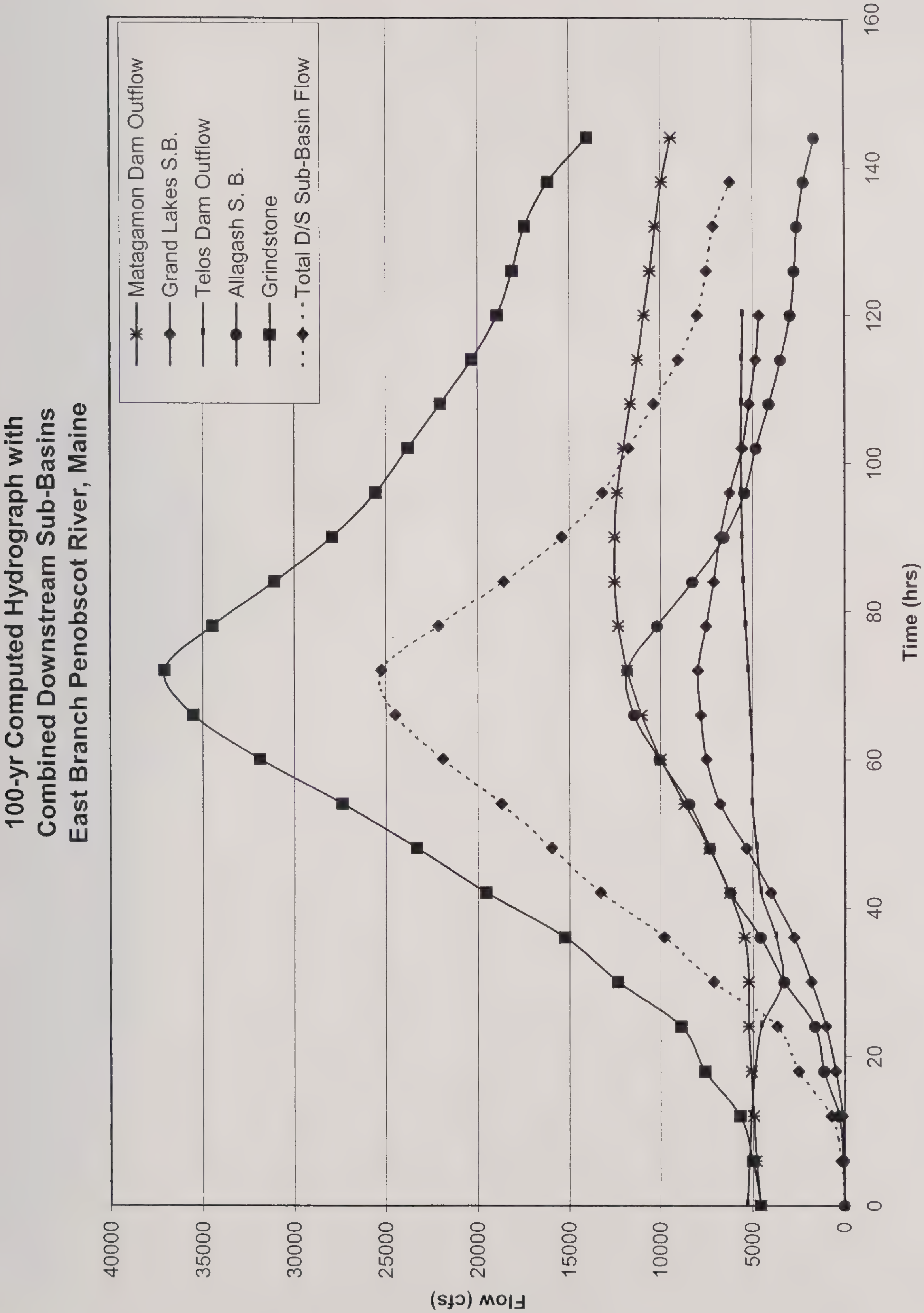


Plate 10
100-Yr Computed Hydrographic with
Combined Downstream Sub-Basins
East Branch Penobscot River, Maine

APPENDIX A

HEC-HMS SUMMARY OF RESULTS

HMS * Summary of Results

Project : penob2   Run Name : Run 238

Start of Run : 16Sep99 0000   Basin Model : 1999 UH 12/20/01
End of Run : 23Sep99 2400   Met. Model : 1999 3-hr UH
Execution Time : 07Feb02 1109   Control Specs : sept 1999

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
Allagash S.B.	4610.3	18 Sep 99 1200	22140	240.000
Telos Dam	725.00	18 Sep 99 1800	8740.1	240.000
Grand Lakes S.B.	3006.3	18 Sep 99 1200	19890	256.000
Matagamon Dam	2589.9	20 Sep 99 0300	24726	496.000
Localized S.B.	3721.5	18 Sep 99 1200	17872	243.000
Seboeis River S.B.	1783.8	18 Sep 99 1200	12340	173.000
Junction-1	6963.0	18 Sep 99 1200	54939	912.000
Wassataquoik Stream	2191.5	18 Sep 99 1200	10576	114.000
Mud Brook S.B.	2401.1	18 Sep 99 1200	11583	59.400
Grindstone	11555	18 Sep 99 1200	77098	1085.400

HMS * Summary of Results

Project : penob2 Run Name : Run 275

Start of Run : 16Sep99 0000 Basin Model : UH Comb. 99 UH

End of Run : 23Sep99 2400 Met. Model : 1999 3-hr UH

Execution Time : 20Jun02 1137 Control Specs : 99 3-hr UH

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
llagash S.B.	4610.3	18 Sep 99 1200	22150	240.000
elos Dam	725.00	18 Sep 99 1800	8741.0	240.000
ake	3006.3	18 Sep 99 1200	19890	256.000
atagamon Dam	2593.5	20 Sep 99 0300	24735	496.000
ub-basins	9769.2	18 Sep 99 1200	50625	417.000
rindstone	11227	18 Sep 99 1200	75361	913.000

HMS * Summary of Results

Project : penob2   Run Name : Run 256

Start of Run : 22Sep81 0000   Basin Model : UH Comb. 81 UH
End of Run : 27Sep81 2400   Met. Model : 1981 3-hr UH
Execution Time : 07Feb02 1511   Control Specs : 81 3-hr UH

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
llagash S.B.	6473.9	25 Sep 81 1200	33335	240.000
elos Dam	5002.4	26 Sep 81 0300	26726	240.000
rand Lakes S.B.	4540.8	25 Sep 81 0600	28946	256.000
atagamon Dam	7871.9	26 Sep 81 1800	42924	496.000
ub-basins	13917	25 Sep 81 1200	75331	417.000
unction-1	19634	25 Sep 81 1500	118255	913.000

HMS * Summary of Results

Project : penob2 Run Name : Run 255

Start of Run : 02Nov66 0000 Basin Model : UH Comb. 66 UH

End of Run : 07Nov66 2400 Met. Model : 1966 3-hr UH

Execution Time : 07Feb02 1511 Control Specs : 66 3-hr UH

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
llagash S.B.	8355.6	04 Nov 66 2100	42237	240.000
elos Dam	3759.3	05 Nov 66 2400	18529	240.000
rand Lakes S.B.	5611.2	04 Nov 66 2100	37638	256.000
atagamon Dam	7348.8	06 Nov 66 0900	56081	496.000
ub-basins	17808	04 Nov 66 2100	96436	590.000
unction-1	21489	04 Nov 66 2400	152516	1086.000

HMS * Summary of Results

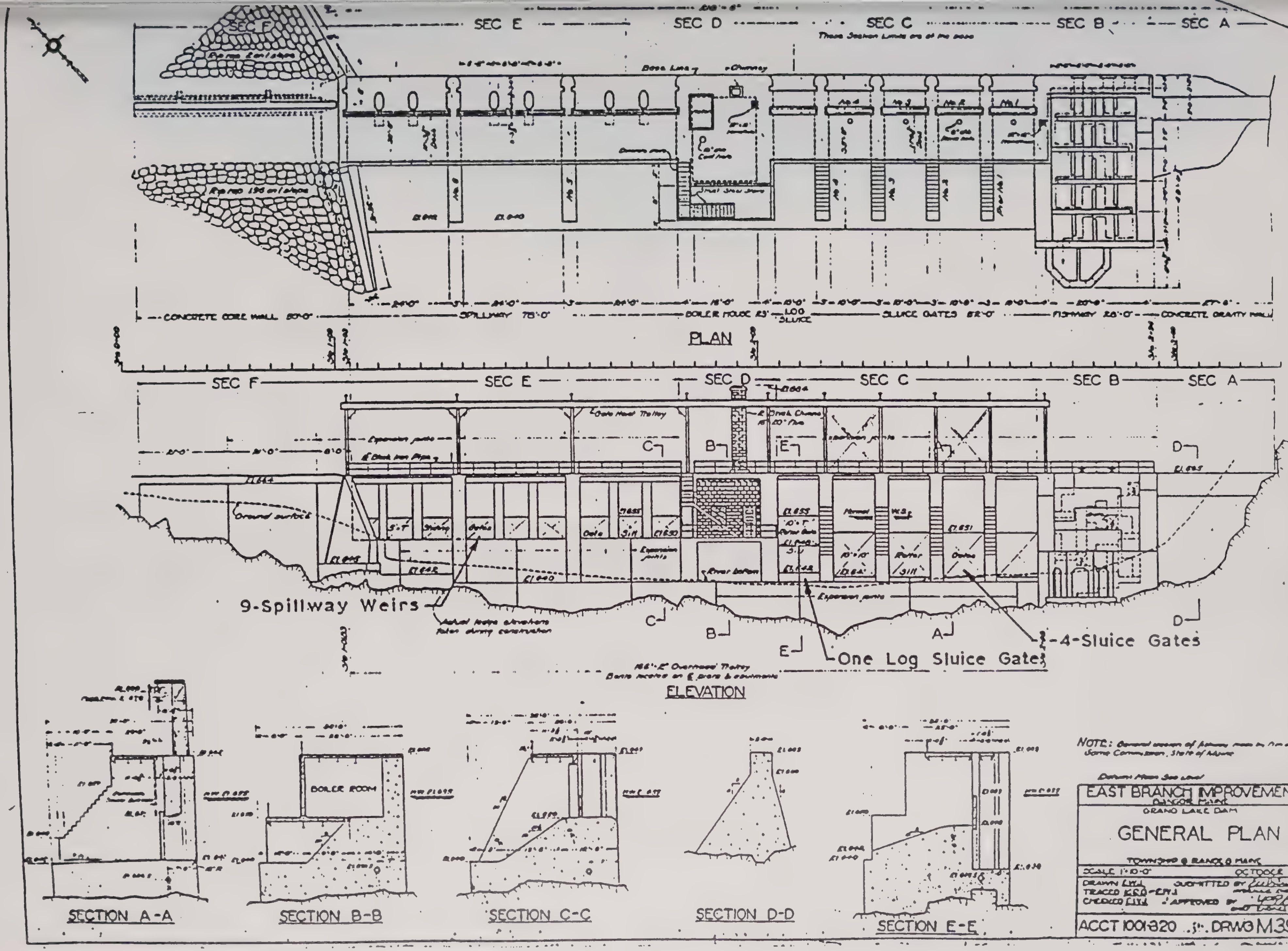
Project : penob2   Run Name : Run 254

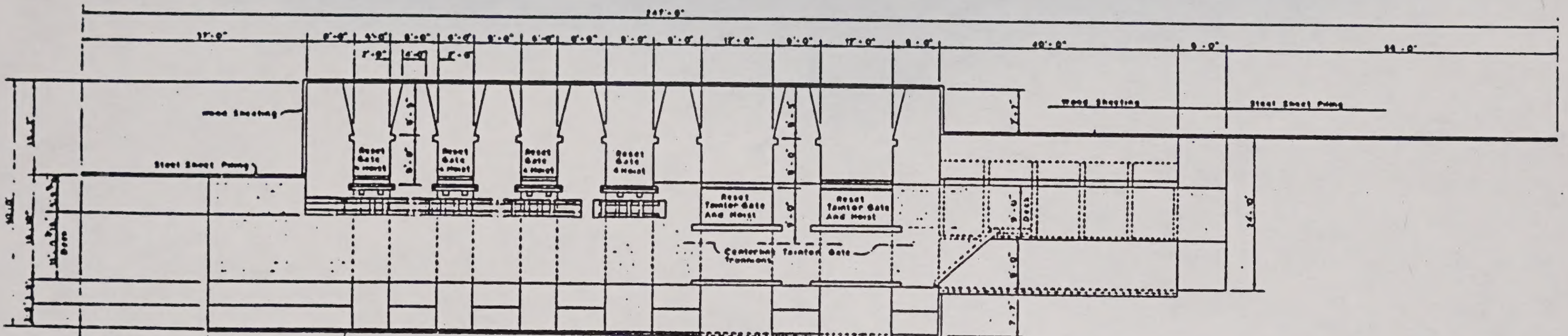
Start of Run : 02Nov66 0000   Basin Model : 100-yr combined UH
End of Run : 07Nov66 2400   Met. Model : 100 yr event
Execution Time : 07Feb02 1506   Control Specs : 100-yr UH

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
llagash S.B.	11953	04 Nov 66 2100	59816	240.000
elos Dam	5616.9	05 Nov 66 2400	60826	240.000
rand Lakes S.B.	7984.2	04 Nov 66 2100	53263	256.000
latagamon Dam	12527	05 Nov 66 1500	108701	496.000
unction-1	12527	05 Nov 66 1500	108701	496.000
ownstream Sub-Basin	25459	04 Nov 66 2100	136627	590.000
rindstone	37076	04 Nov 66 2400	245328	1086.000

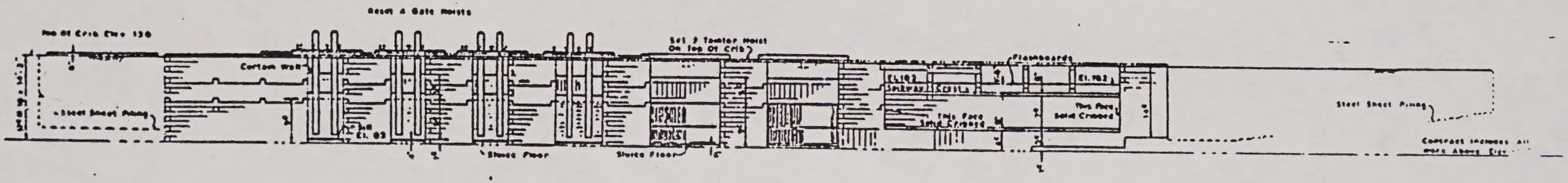
APPENDIX B

MATAGAMON DAM AND TELOS DAM DETAILED FIGURES


SEC F
SEC E
SEC D
SEC C
SEC B
SEC A
CONCRETE CORE WALL 50'-0"
SPILLWAY 78'-0"
BOILER HOUSE 23'
LOG SLUICE
SLUICE GATES 52'-0"
FISHWAY 20'-0"
CONCRETE GRAVITY WALL
PLAN
9-Spillway Weirs
One Log Sluice Gate
4-Sluice Gates
ELEVATION
BOILER ROOM
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
EAST BRANCH IMPROVEMEN
GRAND LAKE DAM
GENERAL PLAN
ACCT 1001-820
DRWG M3



Plan
Scale. 1' = 10'



Downstream Elevation

Telos Lake Dam
M-3248

Telos Lake Dam

M-3248